DOCUMENT RESUME

ED 032 769 EM 007 417

By-Prince, J. D.

A Practitioner's Report: Results of Two Years of Computer Assisted Instruction in Drill-and-Practice Mathematics. For the Period June 15, 1967 to May 30, 1969. Progress Report Number 3.

Stanford Univ., Calif. Inst. for Mathematical Studies in Social Science.
Spons Agency-Office of Education (DHEW), Washington, D.C.
Report No-ESEA-3; OE-BESE
Pub Date May 69
Grant-OEG-3-7-704721-5096
Note-38p.
EDRS Price MF-$0.25 HC-$2.00
Descriptors-*Arithmetic, *Computer Assisted Instruction, *Electronic Data Processing, Elementary School Mathematics, Mathematical Enrichment, *Mathematics Instruction, Tables (Data)
Identifiers-CAI, Elementary and Secondary Education Act, ESEA

The initial purpose of using the Suppes-Stanford CAI Mathematics Drill-and-Practice Program in the McComb, Mississippi, schools was to determine its practicality in a district remote from the developers of the program. It has been found that a significant educational difference exists between groups of children who received computer-assisted instruction and those control groups which received only traditional instruction. The results are especially remarkable among classes of disadvantaged Negro children and appear to be a feasible technique for closing the educational gap between disadvantaged children and those from more affluent segments of society. The McComb schools administration feel that CAI is a visible educational system but that present problems concerning costs, lack of sufficient programs, the plurality of computer languages and the inappropriateness of computer design for educational purposes occasion doubts as to its widespread implementation. Some possible solutions to these problems are suggested. Bibliography, diagrams, and tables are included. (SH)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

ED032769

OFFICE OF EDUCATION CONTRACT
ELEMENTARY AND SECONDARY EDUCATION ACT
TITLE III OEG-3-7-704721-5096

Progress Report Number 3

A PRACTITIONER'S REPORT

RESULTS OF TWO YEARS OF COMPUTER ASSISTED INSTRUCTION IN DRILL-AND-PRACTICE MATHEMATICS

For the Period
June 15, 1967 to May 30, 1969

J. D. Prince, Superintendent
McComb Schools
McComb, Mississippi

McCOMB MUNICIPAL SEPARATE SCHOOL DISTRICT
McCOMB, MISSISSIPPI
IN COOPERATION WITH
THE INSTITUTE OF MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES, STANFORD UNIVERSITY
PALO ALTO, CALIFORNIA

May, 1969

EM007417

THE STATE OF THE ART IN McCOMB

In computer assisted instruction (CAI) such as the drill-and-practice mode developed by Patrick Suppes at Stanford University, educators are not yet dealing with an easily affordable, trouble free, basic system which can be used equally well in all public schools--i.e., a CAI system as useful as the Model-T Ford.

The Model-T was the automobile which put America on wheels; it was cheap, dependable. If an American could afford $300.00 and had a Sears Roebuck catalog, he could dress this functional (but plain) auto up in any manner desired to suit his taste.

Today, CAI programs are more nearly like Duryea's first gas buggy--cranky, noisy, slow, undependable but nevertheless, with enough promise that we can see that CAI can change education in our nation today just as Duryea's smoky, bulky buggy eventually replaced the horse.

How does a school district become interested in CAI and why could it have such an impact upon education in the future? The answer is quite simple. CAI individualizes instruction.

Southern school districts with high percentages of disadvantaged children have particular concern with educational systems which individualize instruction.

We are now convinced in McComb that computer assisted instruction can individualize instruction. After a year of operation in

McComb Municipal Separate School District, we found that significant educational difference existed between groups of children on CAI instruction and children in control groups.

Our findings in the second year of operation show there is little significance between groups of high income, high I.Q. children on CAI and regular instruction (if teachers are comparable in ability) but startling results are obtained in favor of CAI in Negro and low income groups regardless of teacher ability.

If statistical results obtained in the McComb program can be replicated in other southern school districts, CAI drill-and-practice programs can make a significant difference in improving education in the South.

But first, this program must be practical in the sense that it can be easily attained in a poor school district before it can make a measurable educational impact. Is the program practical?

A PROJECT TO DETERMINE IF CAI IS A PRACTICAL PROGRAM

A computer assisted program which serves only a limited segment of a school district's population is not practical. Admittedly it is an interesting device necessary for educational development, but to be viable, a computer assisted instruction must serve all of the pupils in the school district who could benefit from its program at a reasonable cost.

The initial purpose of the McComb project was to determine the practicality of the Suppes-Stanford CAI Mathematics Drill-and-Practice Program in a school district remote from the developers of the program. The first answer sought was, "Is this a viable educational technique suitable for use in a regular classroom setting?"

From the start, the McComb School District personnel had the intention of attempting to carry on a working CAI program within the three year format required by Title III of the Elementary and Secondary Education Act of 1965.

Entering the program on a very limited basis, this first program anticipated as goals: operating relatively few terminals in the McComb area, determining the difficulties of training staff, determining the impact of the program on administrative procedures amd determining the effectiveness of the program in producing some measurable results in educating children of all races.

Some developmental costs were paid to the Suppes' Directed Institute for Mathematical Studies in the Social Sciences during this period. The school district had responsibility only to select staff, coordinate instruction locally and accept some limited technical responsibility.

Suppes' group accepted responsibility for retraining the 21 staff members in a month-long workshop on the Stanford campus in July, 1967.

All signal was generated at the California site during this first year.

The second phase (year) of this project was to determine if every elementary child in the school district could be given the CAI drill-and-practice program from the California location. In addition, attempts to develop low cost hardware necessary to deliver locally whatever programs could be obtained were placed in progress.

Numbers of terminals operating were increased from twenty (20) to sixty (60). Teaching staff totaling sixty had to be trained, though local technical staff remained the same.

The third year of the McComb Project proposed the implementation of a system which would generate CAI signal locally. This system would of necessity still be financed by Title III of the Elementary and Secondary Education Act but would be aimed in a direction intended to become self-supporting after the termination of the third year's ESEA Title III funds. The third year program

would essentially consist of the combining of a local data processing program with the Suppes' CAI Program and any other viable CAI instructional program available.

Hopefully, the selling of data processing services by the local school district to a regional area now served (offering such services as financial accounting packages, student personnel records, report cards, attendance, test grading, norming and other data processing services) in addition to delivering some CAI programs out of the district would support a reasonable amount of the cost of the hardware for the program.

THE HARDWARE AND SOFTWARE: A COMPUTER WITH BELLS AND WHISTLES!

Progress Report Number I[1] best describes the Stanford hardware configuration:

> Programs at the IMSSS, Palo Alto, are handled by a PDP-1 computer. This computer is the product of the Digital Equipment Corporation of Houston, Texas.
>
> The PDP-1 is arranged to interface with a smaller PDP-8 computer. The PDP-1 can read and write the memory of the PDP-8. The PDP-8's function is to store transmission from incoming telephone lines until such information can be utilized by the PDP-1.
>
> The PDP-1 has
>
> --5.35 micro-second machine cycle time
> --32 K of 18 bit memory
> --two high speed data channels, one controlling a disc file of 100 million character storage. The other channel controls a CRT (television tube) display system for visual check-out of stored data
>
> Other features of the PDP-1 are:
>
> --A 16 channel interrupt system
> --double memory (this means that it can perform two functions at the same time)
> --track swapping drum
> --an index register
> --analog to digital conversion and digital to analog conversion
> --high speed paper tape reader and punch
> --microtape magnetic drive unit
> --random access audio unit for use with a spelling program

---

[1]J. D. Prince, A Practitioner's Report on the Impact of Computer Assisted Instruction in Mathematics on a Total School District Not in Physical Proximity to the Developers of the Program, A Report to the U. S. Office of Education on Project OEG-3-7-704721-5096, for the period June 15, 1967, to January 1, 1968. (Mimeographed Bulletin, McComb Public Schools), pp. 5-8.

The basic communication unit is the smaller PDP-8. There are two, one in the computer center at Palo Alto, the other at the data processing center at the school administration building in McComb.

The PDP-8 is a general-purpose, stored-program computer, featuring a 1.5 microsecond random access core memory, a fast arithmetic processor, and a buffered input-output control. The basic system includes 4096 words of 12-bit ferrite core memory, keyboard-printer and tape reader-punch, eight auto-index registers, wired-in, program interrupt, data interrupt, and indirect addressing, teletype multiplexer for 21 TTY's and a high speed data line interface.

Specifications for the PDP-8:

--Word length: 12 bits
--Memory: 4096 words, cycle time 1.5 microseconds
--Add Time: 3.0 microseconds
--In-Out Transfer Rates: 7,992,000 bits per second

Long Lines Telephone Service

A 1829 mile microwave transmission system is provided by American Telephone & Telegraph Company for communication between Stanford and McComb. The transmission follows this route: Palo Alto-San Francisco-Salt Lake City-Omaha-Jackson, Mississippi-McComb. The line provided is a four channel high-grade voice line which permits simultaneous sending and receiving. The line is open 24 hours per day.

Transmission is by audio signal converted by a 201B1 Data Set at either end of the line. This data has the capability of handling 2400 bits of information per second with less than 24 errors in any one hour period.

Service from AT&T has been virtually trouble free.

Hardware Located in McComb

The telephone line arriving in McComb is tied directly to a PDP-8 computer. This computer receives signals from California, transmits the signal to the proper teletype machine, activates the TTY terminal and in turn receives the signal generated as the student depresses a key on

the teletype for the proper response, stores the signal received until the line to Palo Alto is clear, then transmits the signal. The McComb PDP-8 computer is a switching unit keeping the traffic properly ordered among the 21 McComb area TTY's while controlling transmission between Stanford and McComb.

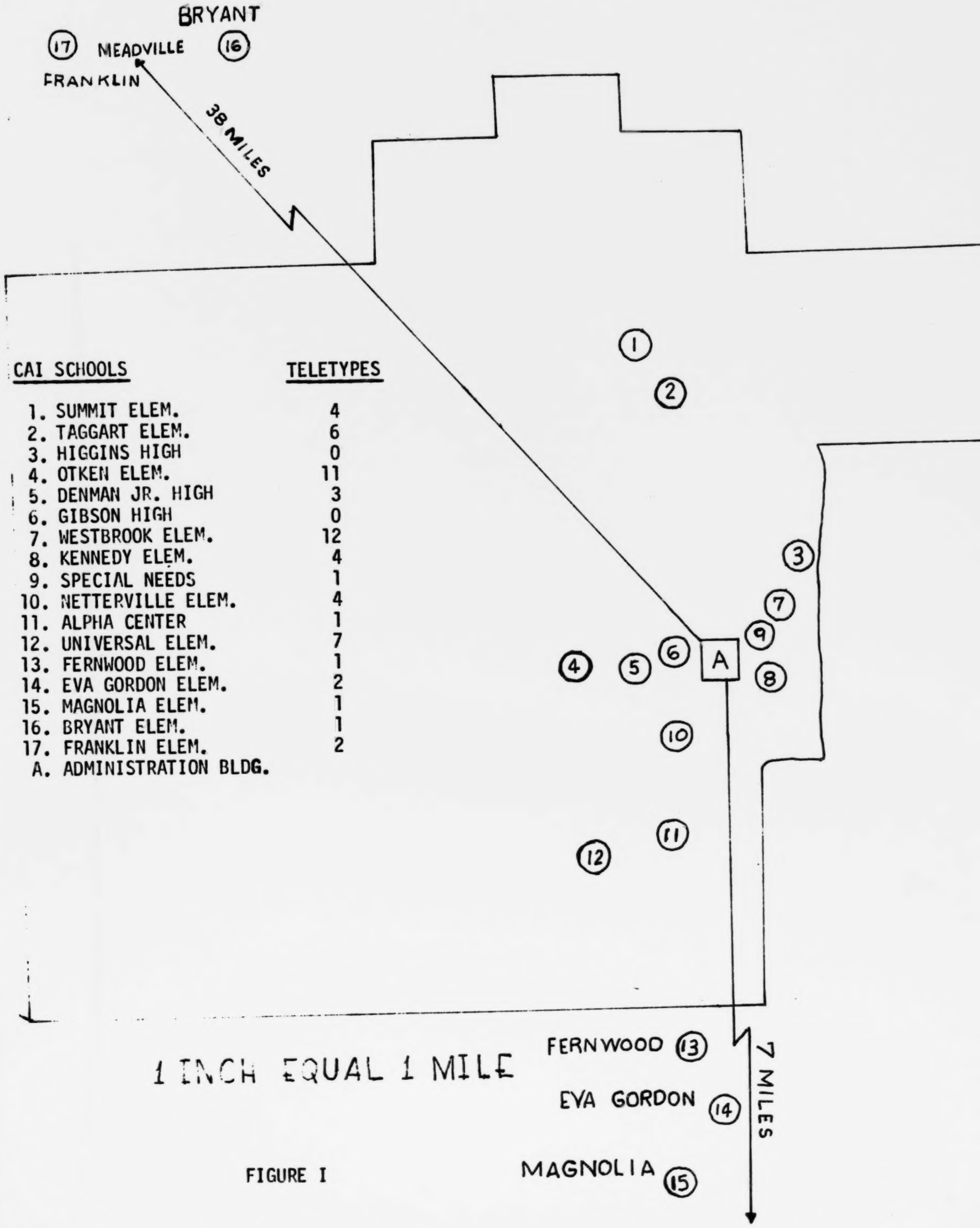
INSERT FIGURES I, II, AND III ABOUT HERE

There are 21 teletype machines located in the McComb area. Fifteen are in the McComb School District, two in the South Pike School District, while three are located in the Franklin County District. All fifteen of the teletypes at South Pike are approximately six miles from the McComb center and the teletypes in Franklin County, while only 40 miles away geographically, are 160 miles from McComb by telephone line as the microwave signal travels.

The 103F data set is vital to the proper transmission of signals to the teletype machine. The TTY terminal transmits a signal which must be converted to an audio signal. These data sets have these characteristics:

--Bit rate - 0 to 200 bits per second
--Operate in temperatures from 40 to 120° F.
--Power consumption - Approximately 15 to 20 watts at 60 cps
--All functions of data set are controlled by the teletypewriter
--The data set converts signals from the teletypewriter (contact closure or open) into voice frequency tones. These frequencies are transmitted over the private line to distant station. The receive data set converts frequencies received from the line into proper form for teletypewriter use
--Channel frequency

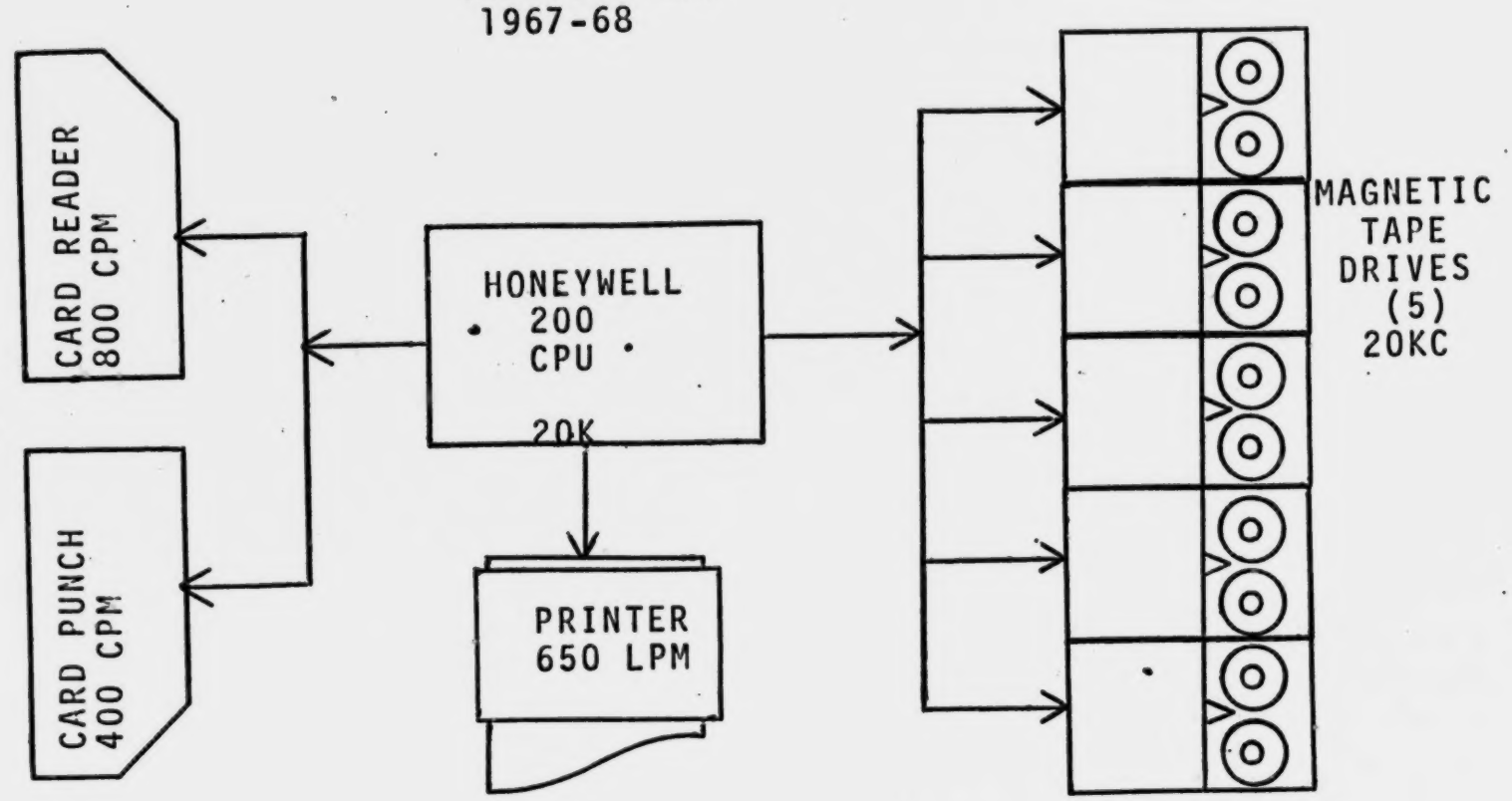
Originating -	Mark	(F_1M)	1270 cps
	Space	(F_1S)	1070 cps
Answering -	Mark	(F_2M)	2225 cps
	Space	(F_2S)	2025 cps



CAI SCHOOLS	TELETYPES
1. SUMMIT ELEM.	4
2. TAGGART ELEM.	6
3. HIGGINS HIGH	0
4. OTKEN ELEM.	11
5. DENMAN JR. HIGH	3
6. GIBSON HIGH	0
7. WESTBROOK ELEM.	12
8. KENNEDY ELEM.	4
9. SPECIAL NEEDS	1
10. NETTERVILLE ELEM.	4
11. ALPHA CENTER	1
12. UNIVERSAL ELEM.	7
13. FERNWOOD ELEM.	1
14. EVA GORDON ELEM.	2
15. MAGNOLIA ELEM.	1
16. BRYANT ELEM.	1
17. FRANKLIN ELEM.	2
A. ADMINISTRATION BLDG.	

FIGURE I

DATA PROCESSING CENTER
CAI 1ST YEAR
1967-68



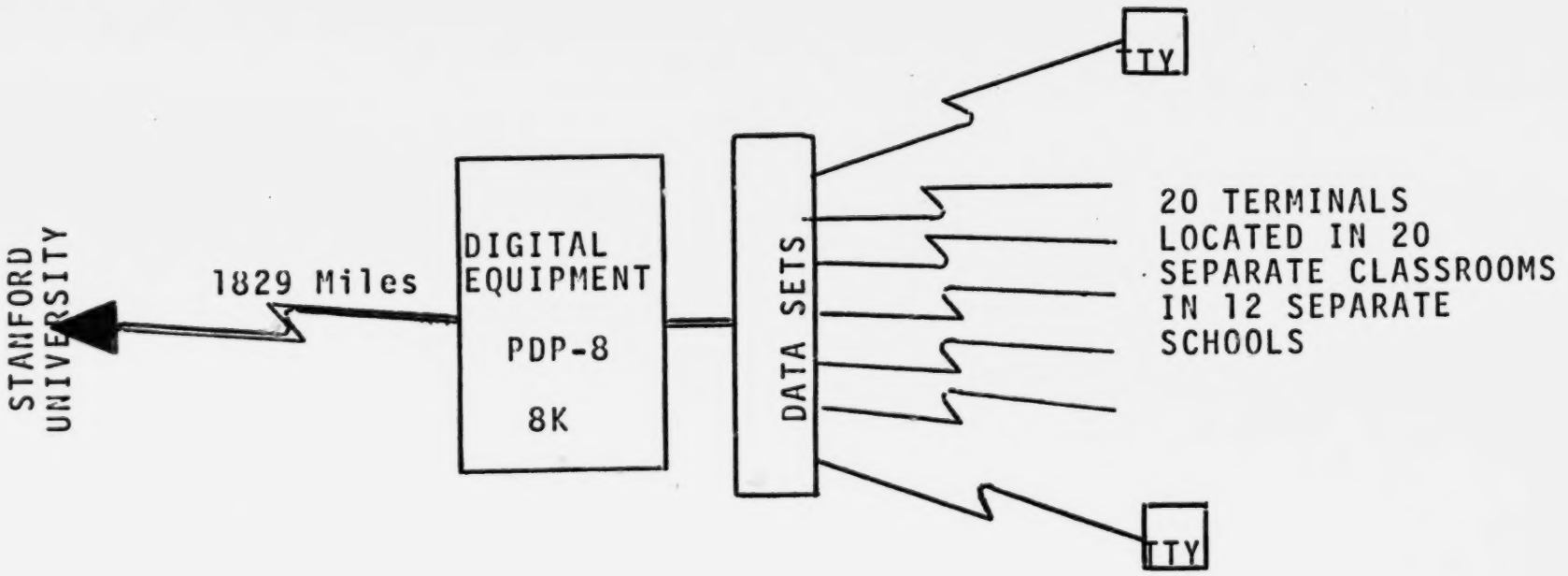
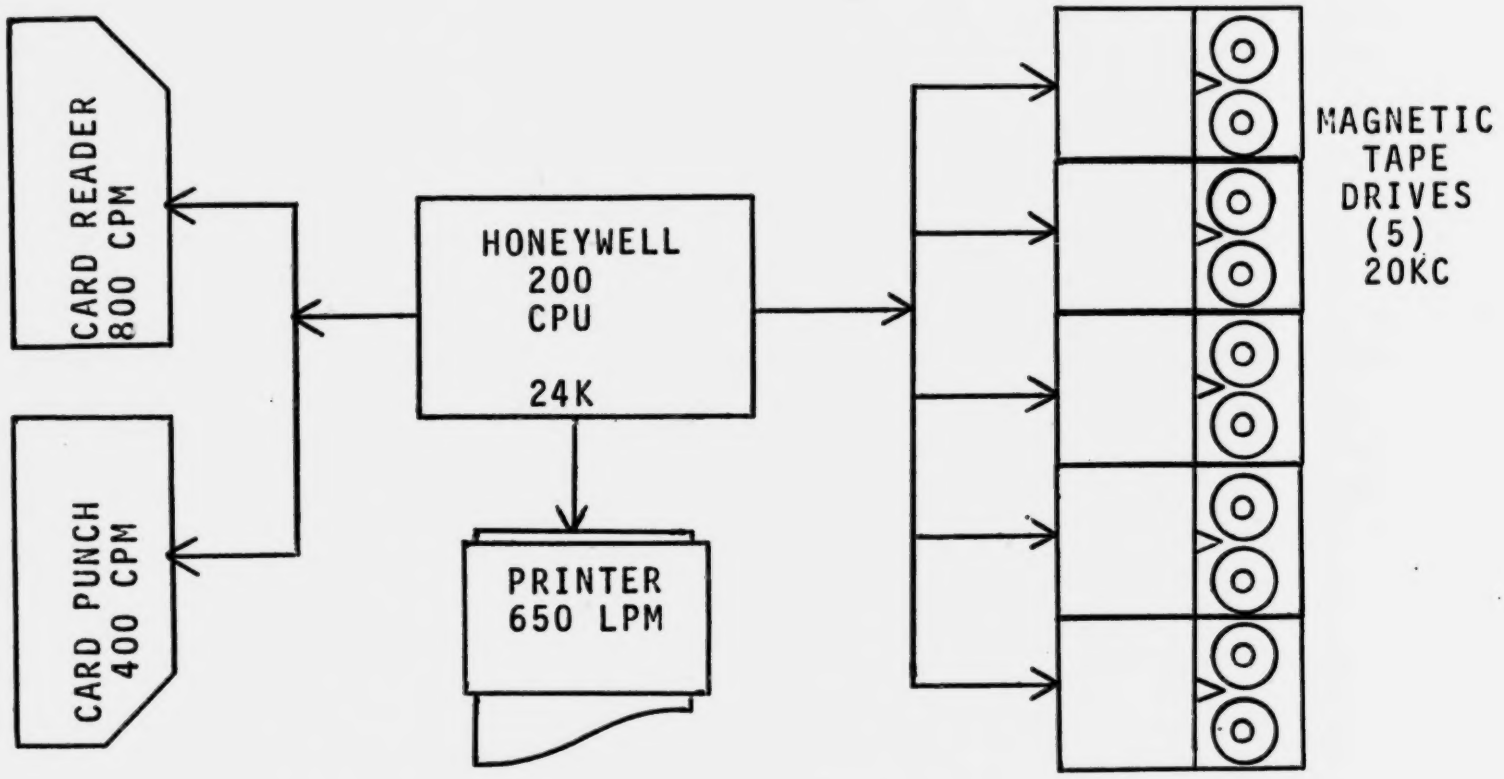


FIGURE II

DATA PROCESSING CENTER
CAI 2ND YEAR
1968-69



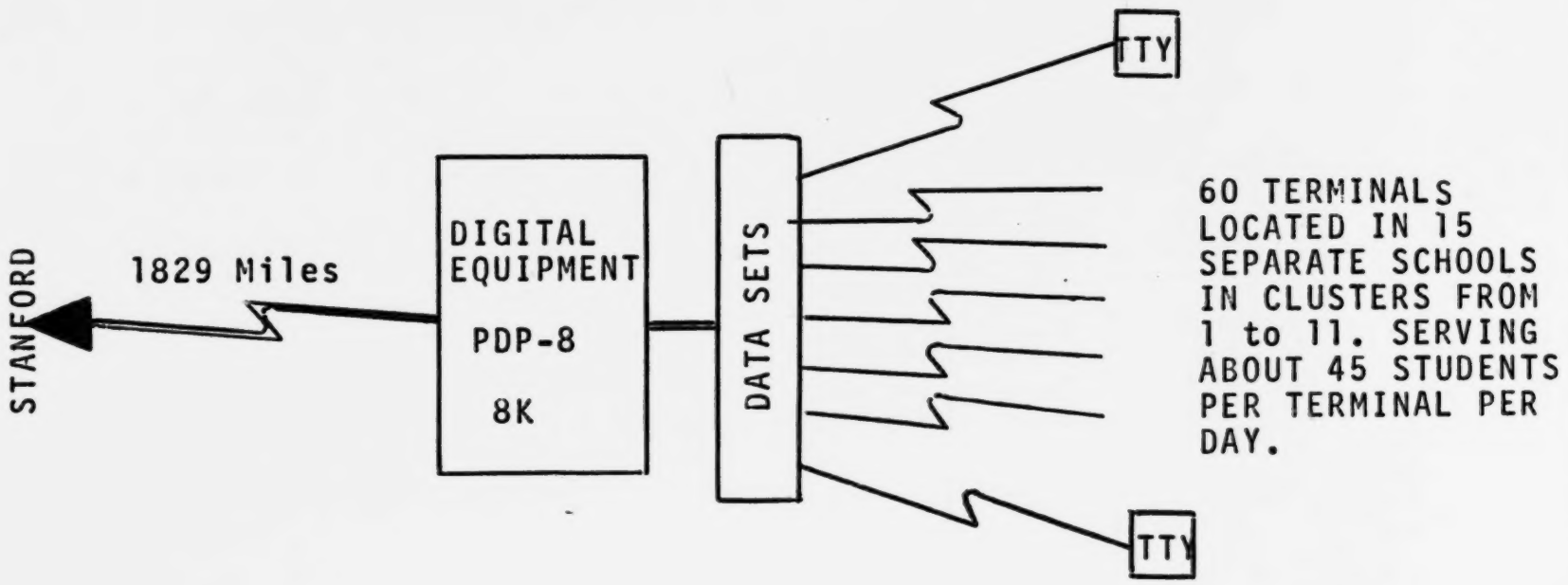


FIGURE III

Equipment Maintenance

> The teletype machines are the standard model 33 teletypewriter machine (TTY) produced by the Teletype Corporation of America of Skokie, Illinois. Modifications are made in the type face and keyboard to suit the TTY's for mathematics instruction. These machines are not heavy duty machines and, as a consequence, require constant maintenance. One machine is kept in reserve for each ten machines in operation. The majority of repairs necessary are of minor nature and can be fixed on site. All TTY's are owned and serviced by the local district.

The hardware for the second year of the program was very much like the hardware for the first year; in fact, the year began identically with the exception that sixty (60) terminals were in operation rather than twenty-one (21). The PDP-1 was used until December 4, 1968. After that time the programs have been driven by a PDP-10 computer--which has the advantage of greater internal speed and 64K of 18 bit memory.

Initially we had great fear of the operating capacity of the Model 33 Teletype machine. The operating life of this machine was given as 4,500 hours by the firm. Certainly the light machine (as contrasted with heavier models of teletype equipment) did not appear to have a life expectancy compatible with the low financial potential of a public school district.

Happily the Model 33 Teletype experience has been an enjoyable one for 24 months of operation. The machine is quite suitable for heavy duty operation,and operating logs on the 21 machines purchased the first year indicate that all machines are still in

operation with the least number of operating hours being 6,000 hours and the greatest number of operating hours being 12,000 hours. The machine which has operated 12,000 hours is still on original parts. Median hours of operation for the 21 machines is 7,000 hours.

We have no hesitation in recommending that a public school district use this relatively inexpensive terminal in its classroom operation if they use proper lubrication and a routine system of rotating machines out of operation for periodic maintenance.

For detailed information on the software programs driving this elaborate computer set-up we recommend the reader see Patrick Suppes' Computer-Assisted Instruction: Stanford's 1965-66 Arithmetic Program.[2]

---

[2]Patrick Suppes, Max Jerman, and Dow Bryan, Computer-Assisted Instruction: Stanford's 1965-66 Arithmetic Program (New York: Academic Press) pp. 187-290.

PEOPLE: TEACHERS, PUPILS, ADMINISTRATORS, PATRONS-- CAI IN OPERATION

We find that children of all ages adjust quite easily to the CAI drill technique, although first graders are not introduced to the teletype terminal until the second semester of their first year.

Informal observations by the aides assigned to monitor the teletype terminals indicate that adjustment to the terminal comes in inverse ratio to the age of the youngster after grade 1; i.e., second graders adjust easier than third graders, third graders easier than fourth graders, etc. The adjustment period is never long in any case.

First graders, particularly those from disadvantaged homes, require slightly longer periods of adjustments to the terminal. The second semester of the first grade sees the largest majority of first grade children able to deal with the CAI technique quite easily.

Drill-and-practice in the CAI mode has been accepted readily by the teaching staff of the McComb Public Schools. Although the school district is the first in the nation to achieve saturation, that is, have all elementary children taking mathematics using the CAI drill-and-practice technique. Saturation was achieved in September, 1968. Classroom teachers and children accept this program

with an almost blase air. One senses that the operating program is a matter of no immense consequence in the normal operation of the daily schedule in an elementary school.

The adjustment of the classroom teacher to CAI instruction is purely an individual matter seemingly independent of age or training of the teacher.

Many teachers professed a greater fear of retraining in mathematics (prior to this program's implementation traditional elementary mathematics instruction was the order of the day) rather than fear of learning equipment techniques necessary to operate the program.

The common experience with McComb District teachers has been that any fear of the program rapidly vanished upon exposure to the system in action and was soon replaced by enthusiasm for the entire arrangment.

The CAI drill-and-practice technique apparently generates this reaction because it has immediate benefit for the teacher. A common teacher report is that CAI unquestionably re-enforces the mathematics learning of the children and at the same time removes some of the drudgery of paper grading in drill-and-practice which the teacher had formerly associated with mathematics.

Several teachers who previously indicated feelings of inadequacy as mathematics teachers who now use the program indicate that they feel considerably more confident in this area. One professes to

enjoy teaching mathematics for the first time in her long teaching career.

Training the classroom teacher is not as complex a problem as once thought.

The first twenty classroom teachers who were trained for the McComb program journeyed to the Stanford University campus and spent eight hours per day, five days a week, for a month on-site taking a course in modern mathematics, a practicum in the operation of the CAI terminal, and receiving instruction in modern techniques of teaching elementary mathematics.

Such a lengthy period of classroom instruction is not necessary for the teacher. Basic needs are a course in modern mathematics as is taught in any school of education and one week practicum (approximately 20 hours of instruction) which combines use of the terminal, understanding of the program, and descriptions of various services which are available through the CAI drill-and-practice program.

Teachers who have received the shorter training period apparently do as well as those teachers who traveled to Stanford University to complete their program.

One practice that has resulted from our school district's experimentation with CAI mathematics is that the upper grade elementary teachers have a tendency to consolidate their mathematics instruction under the wing of teachers who prefer mathematics.

Although this has not become a standard practice in our school district, teachers in the elementary schools where this has occurred report satisfaction with this technique.

Parents and other patrons of the school district have responded most warmly to computer assisted instruction as a part of our school operation. During the first year of the program, when slightly more than 500 children were enrolled, much parental concern was expressed that all children be included. One can imagine that such expressions came from parents whose children were not working at a teletypewriter terminal.

During the spring of 1969 we have had some patron concern that "we may" lose this program after federal funds are terminated. Many expressions of support and words of encouragement to continue CAI in the school district have been received.

A pure testimony that the program is a "public relations success" is indicated by the requests for speeches to PTA's and civic clubs in surrounding cities. The demand for such programs is so heavy that several "teams" are on the road constantly.

IS THE SUPPES' DRILL-AND-PRACTICE PROGRAM A VIABLE INSTRUCTIONAL SYSTEM?

1967-68 Results

Children learn mathematics skills using the CAI drill-and-practice technique remarkably well. During the first year of the program, 544 McComb children in grades 1-6 were enrolled in the experimental group and 515 children were matched in the control group. Pre-testing and post-testing were done of both control and experimental groups. Test conditions were rigidly controlled in all test situations.

INSERT CHART NUMBER 1 ABOUT HERE

In all six grades, results were statistically significant that the experimental group could achieve better on an achievement test measure in skill building than did the control group.

The Suppes' CAI program was not designed to develop skills in arithmetic concepts and arithmetic application. As you may note, test results showed there were three groups in these two areas where significant results were obtained and one group where negative results were obtained.

No effort is made to racially identify any of the first year test group in Chart 2.

These results were not sufficient, however. We asked these questions: How did the experimental and control children do when

STATISTICAL RESULTS

Experimental VS Control Groups - - Suppes (Stanford) Mathematics Drill and Practice

Location and Grades: McComb Public Schools, McComb, Mississippi, Grades 1-6
Dates: Pre-test September, 1967 Post-test May, 1968
Test: Stanford Achievement

		Mean Pre - test				Mean Post- test		Mean Post-Pre Test		Post - Pre Test		
		Control	N	Exp.	N	Control	Exp.	Control	Exp.	t - score	P	df
Arithmetic Computation	Grade											
	1	1.19	62	1.41*	52	1.47	2.55	.26	1.14	3.69	<.01	112
	2	1.96	54	1.99	25	2.80	3.37	.84	1.42	5.23	<.01	77
	3	2.76	56	2.82	22	4.04	4.85	1.26	2.03	4.64	<.01	76
	4	2.45	77	2.26	58	3.17	3.36	.69	1.10	2.63	<.01	131
	5	3.71	134	3.09	83	4.60	4.46	.90	1.37	3.43	<.01	215
	6	4.36	160	4.82	275	5.48	6.54	1.13	1.72	5.18	<.01	433
Arithmetic Concepts	Grade											
	3	2.97	56	2.83	22	4.26	4.78	1.29	1.95	3.01	<.01	76
	4	2.31	77	2.65	58	3.06	3.01	.74	.36	-2.25		
	5	4.00	134	3.42	83	5.24	4.78	1.29	1.37	.50		
	6	4.88	160	5.34	275	5.39	6.31	.52	.98	3.74	<.01	433
Arithmetic Applications	Grade											
	4	2.88	77	2.89	58	3.28	3.33	.41	.44	.22		
	5	4.12	134	3.56	83	4.73	4.33	.65	.77	.88		
	6	4.52	160	5.06	275	5.06	6.13	.61	1.08	4.09	<.01	433

* Grade equivalence in years and months

CHART 1

teachers were equally trained? How do children of different racial groups perform? What type of retention of skill building is retained over the summer vacation? These questions are but a few statements which we have put to statistical analysis. Some of these results are detailed below.

Teacher-vs-Teacher When Training Is Comparable

Does computer assisted instruction influence performance on achievement tests when two teachers are equally trained yet one does not use the CAI technique? This question can be best answered by an experiment conducted during the 1967-68 year by two six grade teachers at Westbrook School, Mrs. Mildred Long and Mrs. Odessa Holmes.

Both teachers attended the complete training school given at Stanford University in the summer of 1967. Both teachers have approximately the same number of years of experience in teaching, have comparable academic training, and are rated as two of the best sixth grade teachers of either race in the school district.

Both teachers taught in adjacent classrooms. During this school year, this school had an entirely Negro student body, although the staff was integrated.

Mrs. Holmes, Negro, taught the sixth grade experimental group of 27. Mrs. Long, Caucasian, taught the control group of 28 sixth grade students. As Long had had Stanford CAI training at the same

grade level in another school (using the CAI drill-and-practice technique), Long was quite familiar with the requirements and the expectations for the Holmes' experimental group. Long made a determined effort to keep her control classwork equivalent to the training given by Holmes. Long used conventional techniques. Both teachers used identical texts.

A comparison of achievement test scores of the experimental and control groups (Table 1) showed the Holmes' sixth grade experimental group able to achieve at a significantly higher level than the Long sixth grade control group.

Table I

Results of Holmes vs. Long

Mean Pre-test				Mean Post-Test				Mean Gain	
Cont.	N.	Exp.	N.	Cont.	N.	Exp.	N.	Cont.	Exp.
Computation (Arith)									
3.5	28	4.0	27	6.2	27	4.5	28	1.0	2.2
Concepts (Arith)									
3.0	25	4.7	27	5.4	27	4.5	25	0.6	0.7
Applications (Arith)									
3.2	25	4.1	27	5.3	27	3.9	25	0.7	1.2

Does the CAI Program Have Marked Effect on First Graders?

The South Central Region Educational Laboratory (SCREL) made a statistical study comparing experimental and control groups at the Universal Elementary School (all Negro first grade) as contrasted with the achievement of a matched pair control group drawn from the all Negro first grade of the Westbrook Elementary School.

In this study the SCREL group ran a testing program independent of that conducted by the McComb-Stanford testing team. The purposes of this research study as stated by the SCREL staff in the summer of 1967 were:

> A pre-test control group design will be used, employing both on-site and remote control groups. The remote control will consist of similar first-year pupils selected randomly from the elementary schools of the district.
>
> Since the CAI component is of primary concern, multi-colored groups will be established to provide interpretable comparisons. These control groups will consist of: (1) the pupils in Section I not drawn to participate in the CAI, (2) the first-year pupils in Section II, and (3) the remote control group described above.

The digest of the SCREL statistical data is revealed in Table II on the following page. These data indicate that the experimental group is able to function more successfully on an achievement test measuring arithmetic skills than in the control group. An interesting sidelight to the SCREL study is that the reading level of the Universal (experimental) group is also significantly higher than is the reading level of the control group.

Table II

CALIFORNIA ACHIEVEMENT TEST

Arithmetic Subtest

Group	N	X Gain	t	p
CAI (E 1)	33	25.12		
Non-CAI				
(C 2)	18	12.78	2.79	<.01
(C 4)	51	16.12	2.83	<.01

Reading Subtest

CAI (E 1)	31	19.97		
Non-CAI (C 4)	48	9.55	3.62	<.01

Interpretation: The test results indicate that E1, those first grade pupils in Universal School who received computer assisted instruction, achieved significantly higher in arithmetic than the two comparisons groups C2 and C4 who received traditional instruction. The E1 group also achieved significantly higher in reading than the C4 comparison group. C2 is a comparison class drawn randomly from Westbrook School. C4 consists of all other first grade pupils in Westbrook School.

CAI and the Intelligent Child From the High Income Home

Our results (Table III) reveal that there is little statistical difference in performance on achievement tests in mathematics when children from high income homes (with average or better I.Q.'s) are compared in the experimental and control groups. Also, we find (Table IV) no significant difference in retention over the summer between these children. The following tables give statistical comparisons between fifth grade children from high income homes at the Otken Elementary School compared with those from even

higher income brackets from the Hughes Elementary School. The Otken group was the experimental group. The Hughes group was the control group.

Both classroom teachers are excellent teachers. Both used modern mathematics techniques. The teacher at the Otken Elementary School had been in the Stanford training program the previous summer.

Table III

OTKEN vs HUGHES SEPT. TO MAY*

	N	Mean Gain Exp.	N	Mean Gain Cont.	Diff	Significant?
Computation	25	1.36	24	1.74	-.38	NS
Concepts	25	1.46	24	.60	.86	$<.01$
Applications	25	.68	24	.90	-.22	NS

Table IV

OTKEN vs HUGHES SEPT. TO SEPT.**

	N	Mean Gain Exp.	N	Mean Gain Cont.	Diff	Significant?
Computation	25	.79	24	.88	-.09	NS
Concepts	25	1.33	24	.65	.68	$<.01$
Applications	25	1.18	24	1.47	-.29	NS

*Testing date late September, 1967, to early May, 1968, seven months of actual instructional time.

**Testing date late September, 1967, to late September, 1968, a lapsed time between tests of twelve calendar months.

Retention of Children from Low Income Homes

In the tables below (Tables V and VI) clear indication is given that disadvantaged children in the experimental groups learn mathematics from the CAI technique (and retain what they learn) better than disadvantaged children in control groups. Universal School is the experimental group in this program in a very disadvantaged area. Westbrook is the control group in an equally disadvantaged neighborhood. All children and teachers were Negro in this particular instance and were at grade level five.

Table V

UNIVERSAL vs WESTBROOK SEPT. TO MAY

	N	Mean Gain Exp.	N	Mean Gain Cont.	Diff.	Significant?
Computation	26	1.65	66	.60	1.05	< .01
Concepts	26	2.23	66	1.59	.64	< .01
Applications	26	1.33	66	.42	.91	< .01

Table VI

UNIVERSAL vs WESTBROOK SEPT. TO SEPT.

	N	Mean Gain Exp.	N	Mean Gain Cont.	Diff	Significant?
Computation	26	1.04	66	.05	.99	< .01
Concepts	26	1.14	66	.04	1.10	< .01
Applications	26	.70	66	.00	.70	< .01

Notice in the table above that concepts shows a marked gain over the summer. Refer to Table III and IV and note that a similar

concepts growth is found in the Otken-Hughes comparison. What does this indicate?

Comparison of CAI Results With Disadvantaged Experimental Group to Advantaged Control Group

An interesting comparison can be made by comparing the performance of the experimental Negro group at Universal School as shown in Tables V and VI with the white control group from the advantaged Hughes Elementary School as shown in Tables III and IV. This comparison is set forth in Tables VII and VIII below. Tables VII and VIII are recompiliation of Tables III through VI.

Tables VII and VIII indicate very clearly that there is very little statistical difference between the educational gains of disadvantaged Negro children on CAI and advantaged white children in a control group taught by normal instructional techniques. This particular finding (which is replicated throughout our statistical results at other grade levels) is an indication that computer assisted instruction may well be a technique suited for closing the educational gap which exists between the disadvantaged and children from more affluent segments of society.

An interesting observation is that the conceptual gain of the Negro students was greater at the end of the year's instruction than was the gain of the class taught by traditional instruction. An interesting sidelight is the significant gain in "applications" of the white group at the time of retesting in

September, 1968.

Table VII

UNIVERSAL vs HUGHES SEPT. TO MAY

	N	Mean Gain Exp.	N	Mean Gain Cont.	Diff.	Significant?
Computation	26	1.65	24	1.74	-.09	NS
Concepts	26	2.23	24	.60	1.63	<.01
Applications	26	1.33	24	.90	.43	NS

Table VIII

UNIVERSAL vs HUGHES SEPT. TO SEPT.

	N	Mean Gain Exp.	N	Mean Gain Cont.	Diff.	Significant?
Computation	26	1.04	24	.88	.16	NS
Concepts	26	1.14	24	.65	.49	NS
Applications	26	.70	24	1.47	-.77	<.01

Conclusions

Computer assisted instruction is a viable educational technique. From analysis of data presented here we could be tempted to infer it is not as successful a teaching technique for children from advantaged homes as it is for children from disadvantaged homes. Further study of available data is imperative in this respect.

WHERE DO WE STAND NOW?

CAI is a viable educational system if the McComb Project is any indicator. CAI as a practical educational concept stands at the brink of a tremendous future, but this future is clouded by several rather severe problems which are faced by all CAI programs. These problems are: (1) expense of hardware, (2) lack of hardware compatable with existing software, (3) lack of sufficient programs, (4) a proliferation of languages in which the software is written and (5) lack of commitment of computer manufacturers to produce equipment tailored to educational requirements.

Our conviction as to the McComb experience with the Suppes' drill-and-practice mathematics program is that to deliver CAI as a viable school program here hinges about the possibility that hardware costs can be cut considerably and communication costs reduced by the use of a technique where a small computer is up dated by a data processing computer. Locally we envision CAI as being delivered as a pheripheral, or fallout, to a data processing program.

Our idea is to utilize the memory of the data processing computer (obviously it would have to be properly programmed to do this task) to update a "batch process" CAI program brought to the big computer from tapes generated on smaller pheripheral

computers. These smaller computers would operate independently of the big computer during the day--not connected by any real time arrangement to the data processing computer by telephone line. The small computer will generate data on tape, which data is up dated during night hours on the data processing computer, thus leaving the data processing computer available for full usage during prime time for school district data processing operations.

Our reasoning has been developed by this train of thought.

For CAI to be delivered at a reasonable cost, it must be delivered by a computer system which has more than one purpose and has no easily reached finite limitation on the number of pupils served.

Computer hardware available on the market at the moment is too expensive to deliver a program at a cost effectiveness which would be supported by a single local school district simply because the CAI mode is not adapted easily to real time data processing equipment. The details of this arrangement are too complex to be set out in this short document, but we can suffice by saying that the switching demands of a terminal require so much computer memory that the number of real time terminals which can be driven by any computer memory can quickly be reached by the number of pupils in any medium size district.

The obvious solution to this dilemma is to remove the switching function from the central processor and use the data processing

computer as it is intended to be used--as a batch processor of information.

We have independently (and exhaustively) investigated all large commercial computer configurations technically capable of delivering CAI. We can state without equivocation that we could not afford to operate any of the systems that we have investigated without federal support.

Examined in detail in our investigation were nine different commercial computer configurations. This examination occupied an eight month period of time in which we received detailed proposals from seven separate firms. Our efforts to find an "affordable CAI system" already on the market terminated in January of 1969.

As a result of our investigations, we have concluded that there must be a way to deliver an "affordable" CAI system, but rethinking the approach taken by commercial computer firms (used to dealing with well financed businesses) was necessary before this goal could be reached for public schools.

A Satellite Computer System

To be "practical" CAI must be salable in even the smallest school districts. Being "salable" means a favorable cost effectiveness ratio. Such a ratio would be measurable in terms of educating pupils within the financial limitations of the district offering the program. We have set arbitrary figure of $20.00 per pupil as a salable figure.

This figure of $20.00 per pupil would be within the same range as one-fifth of the mathematics cost per pupil per year in an average classroom.

We see two major costs in any CAI budget, outside of personnel.

The first is communication. Obviously all students in the school district cannot be handled at a point immediately adjacent to a central processing computer or a satellite computer. At distances beyond 2,000 feet, independent communication devices (either high grade telephone line or micro-wave transmission) must become a part of a CAI network. The telephone line itself is a relatively inexpensive communication device. However, computer impulses (digital in nature) must be translated into an audio signal. This requires a relatively expensive data set at either end of the telephone line. This data-set converts the digital pulse of the computer into an audio signal which can be transmitted over the telephone line. The audio signal must be reconverted to a digital signal at the other end of the line. The rental costs of these data sets run approximately $130.00 per terminal per month. With 40 teletype terminals in operation, data sets become an expensive part of a CAI budget. Circumventing this cost would require owning one's own data sets (purchase cost approximately $500 apiece) or the use of a microwave transmission tower, which system would run in the same cost range as megacycle transmission system for education te

An alternate would be to design a system which would largely eliminate telephone lines or need for microwave communication.

The computer cost is the second immense factor in CAI. A factor limiting real-time systems is the number of terminal devices which can be driven by the computer. The simplest terminal available, the teletype machine, demands computer memory to attend to its mechanical needs. 32-K of 8 bit word memory can handle the necessary computations to perform CAI and drive only 28 teletype terminals without severe impairment of the program. One teletype terminal can handle approximately 45 children in a given day. Thus, using this rule of thumb measure, each 32-K (8 bit) memory can handle 1,440 students in a six hour school day on a real-time basis. Using this figure, the finite limitation of a 256-K memory computer (a very large computer indeed) would be in the vicinity of 12,000 pupils per day using the relatively simple teletype terminal. The cost of this 256K computer per child is out of fiscal reach of any school district unless the school district has some outside source of funds.

An alternative approach would be to design a system in which the memory of the computer is not tied up by this switching function. In this case a satellite switching computer, not operated on a real time basis but with sufficient memory and disc storage to operate programs for one day at a time can be updated at night by a relatively small data processing computer (24K of 8 bit words).

Conclusions

In April of 1969 the McComb District school board let a contract with a firm to develop a satellite computer system up-dated by a Honeywell 200 data processing computer. This computer

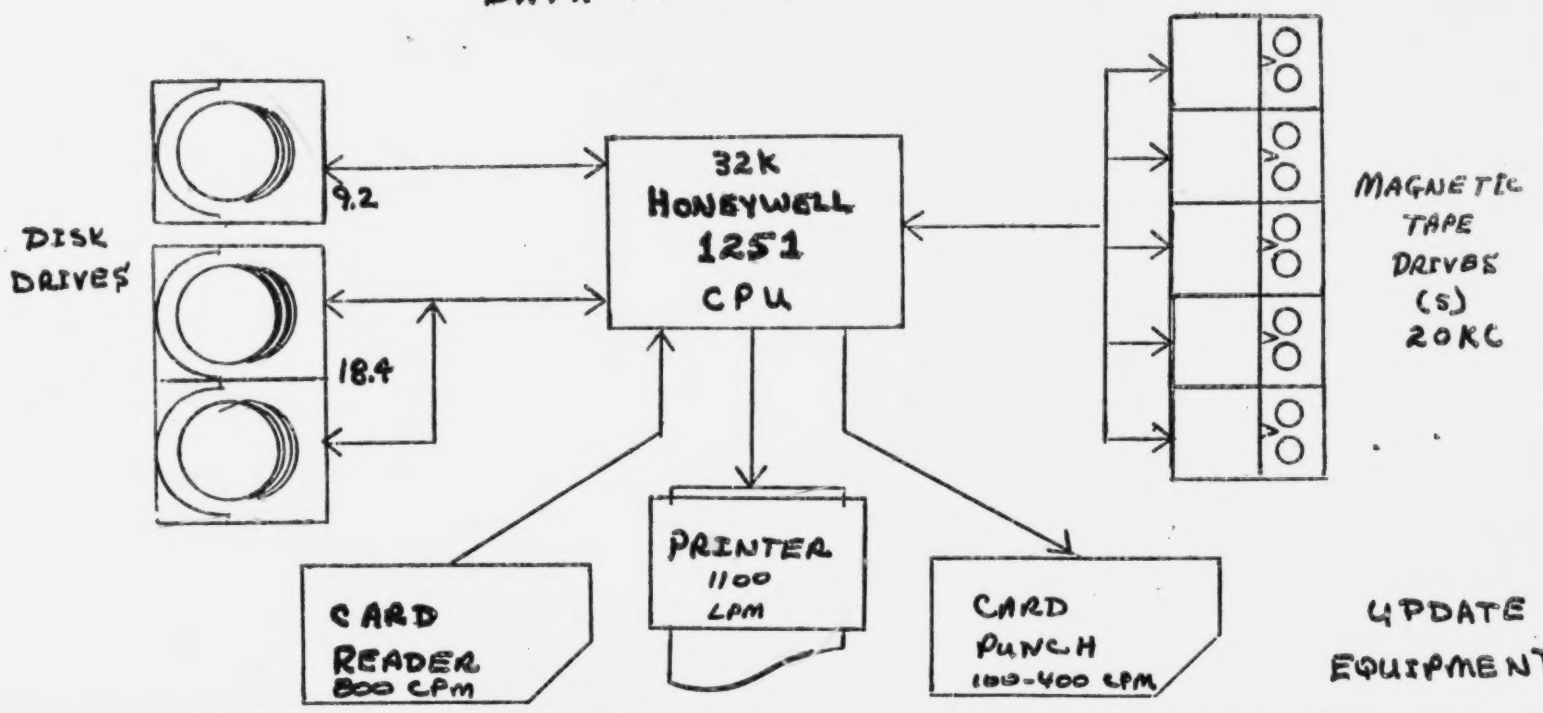
---

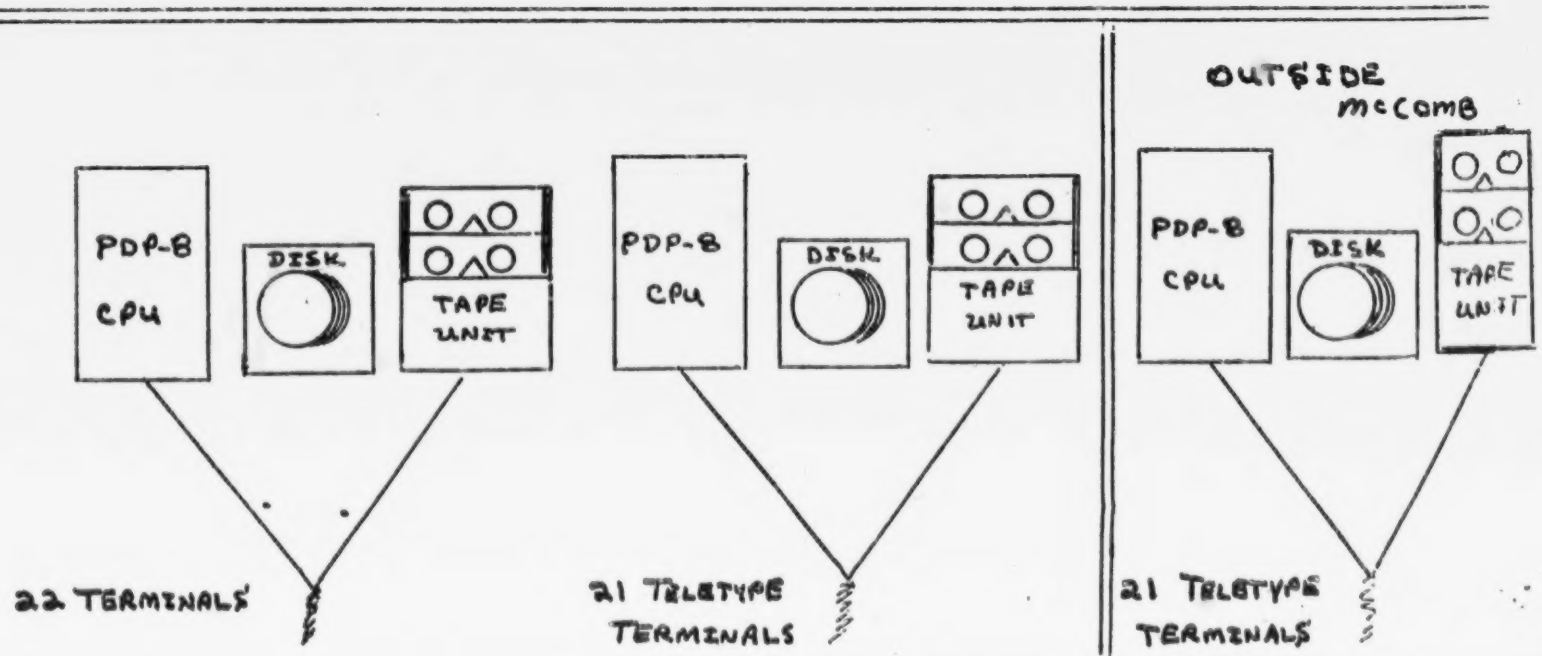
INSERT FIGURES IV AND V HERE

---

configuration meets the requirements of the model described above. The location of smaller computer satellites in large elementary schools in some measure will cut communication costs. The data processing computer is free to do prime time educational data processing. The information necessary to drive the small computers will be up-dated at night by a batch processing procedure.

Hopefully the McComb School District will be able to produce a "practical" computer assisted instructional program in drill and practice mathematics during the third year of its ESEA Title III project.


DATA PROCESSING CENTER
DISK DRIVES
9.2
18.4
32K HONEYWELL 1251 CPU
MAGNETIC TAPE DRIVES (5) 20KC
PRINTER 1100 LPM
CARD READER 800 CPM
CARD PUNCH 100-400 CPM
UPDATE EQUIPMENT


PDP-8 CPU
DISK
TAPE UNIT
22 TERMINALS
PDP-8 CPU
DISK
TAPE UNIT
21 TELETYPE TERMINALS
OUTSIDE McCOMB
PDP-8 CPU
DISK
TAPE UNIT
21 TELETYPE TERMINALS

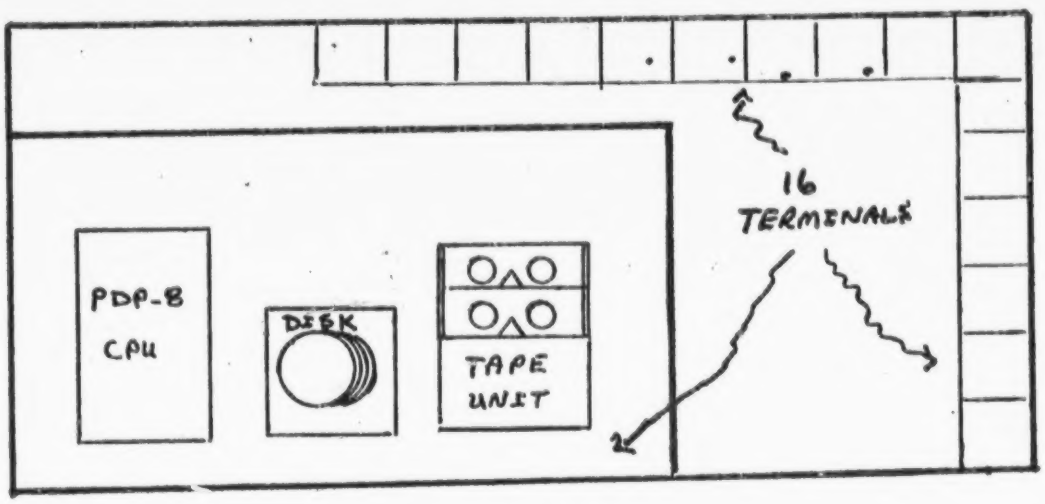

16 TERMINALS
PDP-8 CPU
DISK
TAPE UNIT
WESTBROOK SCHOOL

FIGURE IV

PROPOSED
HONEYWELL SYSTEM
FOR
CAI AND COMMERCIAL APPLICATION

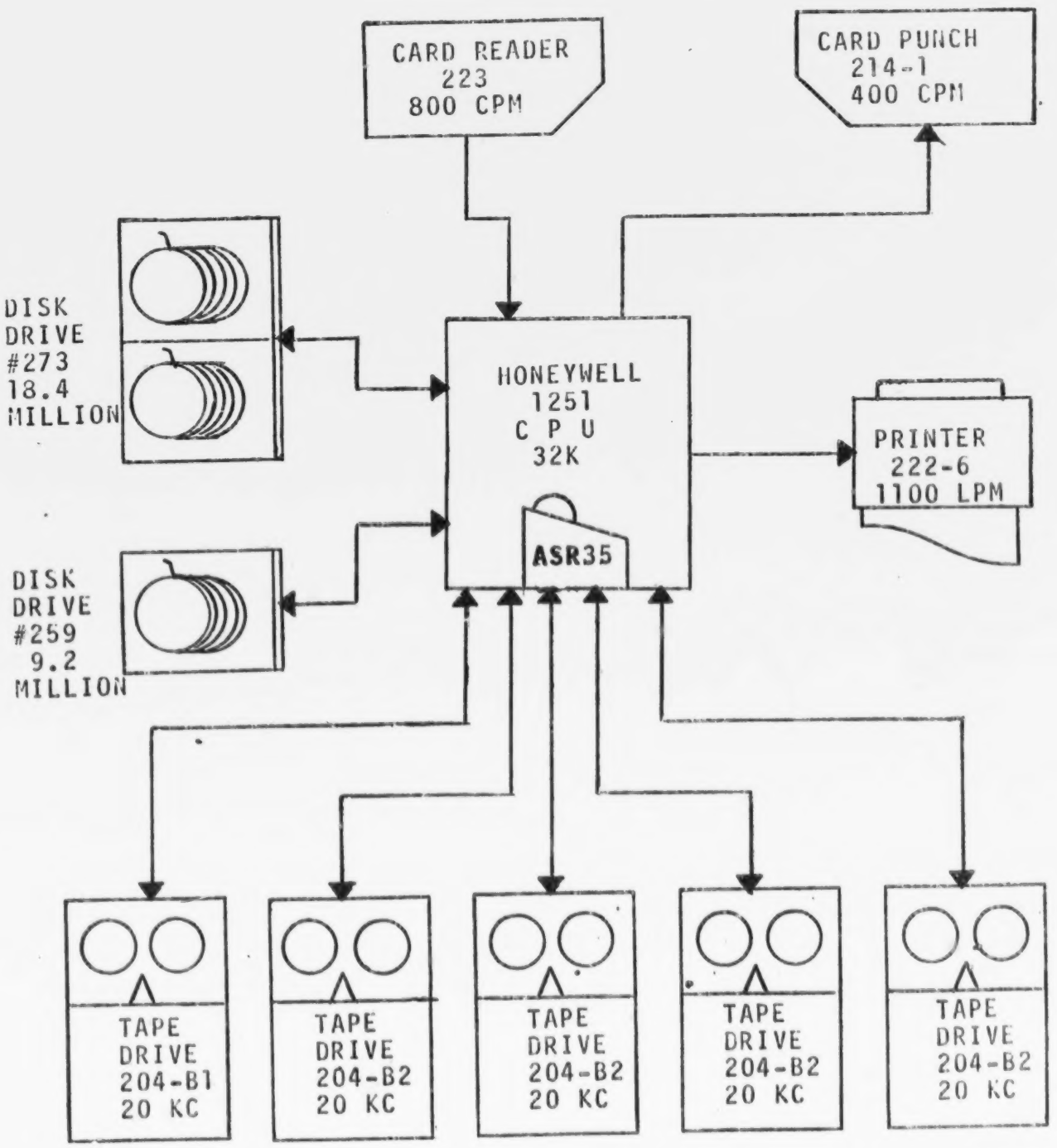


FIGURE V

BIBLIOGRAPHY

Brockman, Ott. "Long Distance Teaching." Southern Telephone News, (January, 1968), pp. 16-19.

Burris, Emily. "Computer Math in McComb Schools." Mississippi Education Association Journal, Vol. 59, No. 6 (March, 1968), p. 24.

Dawson, Kenneth E., and Morris Norfleet. "The Computer and the Student." NEA Journal (February, 1968), pp. 47-48.

Haga, Enoch. "CAI: A Commencement." Business Automation, (November, 1967), pp. 49-53.

Jerman, Max. Teacher's Handbook. Institute for Mathematical Studies in the Social Sciences, Stanford University, (October, 1967).

Pittman, Paul. "An Apple for the Teacher." The Changing Middle South, #4 (1967), pp. 12-13.

Prince, J. D. "Computer Assisted Instruction in the Elementary School." Association for Educational Data Systems Monitor, Vol. VII, No. 6 (January, 1969), pp. 1-3.

Prince, J. D. "Jule Loves Susie." American Education, Vol. 4, No. 4 (April, 1968), pp. 24-25.

Stovall, Gayden. "Long Distance Learning." Audiovisual Instruction, Vol. 14, No. 3 (February, 1969), pp. 20-23.

Suppes, Patrick. "Accelerated Program in Elementary-School Mathematics--the Second Year." Psychology in the Schools, Vol. III, No. 4 (October, 1966), pp. 294-307.

Suppes, Patrick, "Applications of Mathematical Models Of Learning In Education." In H. O. A. Wold (Scientific Organizer), Model Building in the Human Sciences, Entretiens de Monaco en Sciences Humaines, Session 1964. Monaco: Union Europeenne D'Editions. pp. 39-49.

Suppes, Patrick. "Mathematical Concept Formation in Children." American Psychologist, Vol. 21, No. 2 (February, 1966), pp. 139-150.

Suppes, Patrick. "Modern Learning Theory and The Elementary-School Curriculum." American Educational Research Journal, Vol. 1, No. 2 (March, 1964), pp. 79-93.

Suppes, Patrick. "Tomorrow's Education? Computer-Based Instruction in the Elementary School." Education Age, Vol. 2, No. 3 (Jan.-Feb., 1966).

Suppes, Patrick. "The Uses of Computers in Education." Scientific American, Vol. 215, No. 3 (September, 1966), pp. 207-220.

Suppes, Patrick; Dolly Kyser; and Catherine Braithwaite. Sets and Numbers, Grades 1 through 6. Syracuse, New York: The L. W. Singer Company, 1966.

Suppes, Patrick; Max Jerman; and Guy Groen. "Arithmetic Drills and Review on a Computer-Based Teletype." The Arithmetic Teacher (April, 1966), pp. 303-309.